RESEARCH REPORT CROP YEAR 2006-07

Program: **VDACS – Specialty Agriculture Research Grant – FY07**

Project Title: **Development and Management of Specialty Small Grain Varieties for High-Value End-Use Markets**

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Project Component: Breeding & Development of Specialty Wheat Varieties

The small grains breeding program initiated research focused on the evaluation and development of specialty wheat in 1998. One objective of the program has been to identify and develop soft wheat lines with high-value traits such as white seed color and unique protein quality (strong gluten strength). Another major objective has been to identify and develop hard wheat lines adapted to our region. We continue to interact with producers and millers in Virginia and the region in order to identify and incorporate desirable and high value end-use traits into adapted wheat varieties.

May, 2007 Seedmen's Field Day, EVAREC

During May 2006, a personal tour of Bread Wheat Breeding Nurseries was given to C.J. Lin (Research Director of Mennel's Roanoke City Mill), Don Mennel (President and CEO of Mennel Milling Co.), Michael Barnett (Quality Assurance Manger of Miller Milling Co., Winchester, VA), and three representatives of Gerards Custom Bread Co. including Gary Knight (President and CEO). A large portion of the May 2007 Seedmen's field day held at EVAREC near Warsaw, VA featured varieties and management techniques developed from this research. Grain samples of specialty wheat lines are provided to millers for milling and baking evaluations each year, thereby directly identifying wheat lines having desirable end-use quality that have potential commercial production and/or use as parents in the breeding program.

Analysis of agronomic and milling and baking quality data of entries evaluated in Virginia Tech's Bread Wheat Yield Nurseries since 2003 indicate that the released Hard White Winter (HWW) wheat variety Lakin and the Hard Red Winter (HRW) wheat varieties TAM 110 and Karl 92 have potential for commercial production in the mid-Atlantic region. These three hard

wheat varieties are currently being grown and evaluated in 20 acre pilot plots by three producers to assess their potential for larger scale commercial production. The HRW wheat experimental lines 92PAN2#26 and KS00F5-58-3 also have performed well in both agronomic and quality tests. A small seed increase of these two HRW wheat lines is currently being produced at the VCIA Foundation Seed Farm in anticipation of their release and commercial production. Breeder seed of the latter two lines is being developed at the EVAREC in Warsaw this year, to provide growers with a purer seed source. Breeder seed of 92PAN2#26 and KS00F5-58-3 will be provided to VCIA this fall. Such hard wheat varieties will provide producers with an alternative to the currently grown French variety Soissons until superior varieties are released from breeding programs at Virginia Tech and elsewhere.

Factors limiting small grains production during the past several years add credence to the need to develop and select hard wheat varieties that are adapted to our region. The 2002-03 growing season was likely the worst in the past decade for small grain production and was plagued by excessive precipitation from planting to harvest, which incited and resulted in significant losses in grain yield and quality due to head diseases such as Fusarium head blight (scab) and glume blotch. The 2003-04 growing season was unusual in that hot day time (>85 F) and evening temperatures occurred on more than 15 days in May during the critical grain fill period. These temperature extremes resulted in significant reductions in grain yield and test weight. Hard wheat and European wheat lines, developed in other states or countries, were particularly affected by these disease and environmental stresses primarily due to their lack of adaptation to our region.

Summary of Project Activities to Date

Approximately 235 bread wheat varieties and experimental lines developed by breeding programs in Colorado, Kansas, Nebraska, Oklahoma, South Dakota, Texas, and France as well as 115 bread wheat experimental lines developed at Virginia Tech were evaluated for agronomic performance in yield trials at three locations in Virginia. Following harvest, data from field observations and post-harvest data including grain yield, test weight, and grain protein were summarized and superior lines selected for further testing during the 2006-07 season. Grain samples from selected elite lines were sent to the Hard Wheat Quality Lab in Manhattan, KS for

milling and baking quality analysis and also were provided to Mennel Milling Company in Roanoke, VA for evaluation of end-use quality.

Bread Wheat Elite Trial

During the 2005-06 growing season, 4 strong gluten soft red winter (SRW) wheat lines, 21 hard red winter wheat lines, 3 French bread wheat lines, and 4 hard white bread wheat lines were evaluated for agronomic performance in Virginia's Bread Wheat Elite Test at three locations. Two HRW wheat experimental lines had yields similar to the SRW wheat cultivar Tribute and four other HRW wheat lines had grain yields (90+ bu/ac) similar to Renwood 3260 (Table 1).

Table 1. Agronomic Data for 2006 Bread Wheat Elite Tests -3 Locations- BB = Blacksburg, WR = Warsaw, and PT = Painter.

LINE	Yield Bu/a	Yield Rank	Test Weight lb/bu	Heading Date (Mar 31+)	Height (in)	Lodging (0.2-10)[1]	Leaf Rust (0-9)	Powdery Mildew (0-9)	Early Height (3-27) Inches	Protein %	Gluten %	Zeleny
Locations	All		All	BB WR	BB WR	BB WR	WR PT	All	WR	All	All	All
TRIBUTE	101.0	1	61.8	27.3	30.5	0.2	1.4	0.3	8.0	12.3	23.3	43.1
PIONEER 26R15	100.8	2	58.8	27.8	32.7	0.2	1.6	0.6	9.0	12.5	24.0	45.0
KS970085-9-19	98.3	3	58.5	25.2	29.8	0.2	1.6	1.5	9.5	12.2	21.8	43.6
KS970085-9-15	96.2	4	58.8	25.0	30.3	0.2	1.8	1.1	9.3	12.3	21.8	46.0
RENWOOD 3260	96.1	5	60.8	25.0	32.5	0.2	2.2	0.0	8.5	13.3	26.2	51.1
SX1432W	92.5	6	57.7	29.7	29.0	0.2	2.4	1.1	8.0	12.7	25.3	44.1
PION2643	92.4	7	59.9	25.7	28.2	0.2	1.6	0.4	9.5	12.8	24.0	43.2
92PAN2#26	91.6	8	59.0	28.2	30.8	0.2	3.2	2.8	9.7	12.9	24.8	51.4
TX02D5406	90.1	9	60.2	25.2	29.8	0.2	1.6	0.8	8.8	12.4	22.1	44.1
SC.2209	89.8	10	56.1	28.5	27.5	0.2	1.8	0.0	9.7	12.6	23.9	50.0
BC960048-13	89.6	11	60.1	28.5	32.8	0.2	1.6	4.0	9.8	12.8	23.9	50.9
SOISSONS	88.7	12	58.9	31.0	30.8	0.2	4.4	0.3	8.3	12.4	21.5	40.8
TAM 302	87.4	13	58.5	30.3	34.3	1.5	1.8	2.9	8.7	12.2	22.9	41.0
KS00F5--20-3-2	86.8	14	59.9	23.2	31.0	0.3	1.8	2.3	9.8	13.4	26.2	53.3
TX02D6833	86.4	15	58.0	29.0	33.0	0.2	2.8	1.0	9.0	12.9	27.2	50.7
00F5--58-3	86.4	16	61.2	26.3	31.2	0.3	3.2	1.4	10.0	12.8	24.3	51.5
TX99D4478	84.8	17	58.9	26.3	33.7	0.2	2.6	0.3	8.8	13.7	26.7	55.6
TAM 110	84.4	18	59.9	23.5	33.2	0.7	5.2	0.0	10.8	13.0	25.1	51.6
U3960-3R-3-11-6	83.7	19	58.5	28.3	33.0	0.2	1.4	0.6	8.8	12.9	25.1	53.8
Lakin	83.3	20	60.5	27.5	33.8	0.2	4.2	2.8	9.2	13.4	26.4	56.9
KS00F5--20-3-3	82.5	21	60.0	22.8	32.7	0.2	1.6	1.8	9.7	13.6	26.5	53.6
KS940786-6-11-2	81.0	22	59.9	28.2	32.5	0.3	1.6	5.3	9.7	12.6	22.5	48.1
KS00F5--36-10-1	80.7	23	58.8	25.2	28.5	0.9	2.2	1.4	9.2	13.2	24.4	53.4
KS99011-1-~33	77.4	24	58.9	25.5	29.5	0.2	4.4	1.4	9.3	14.1	28.1	61.0
U3952-2R-1-16-5	77.1	25	56.7	26.0	32.5	0.7	2.4	0.1	10.0	13.5	26.6	52.4
KS03HW82	76.2	26	58.5	27.7	34.3	1.4	1.8	1.5	8.2	12.9	24.8	54.1
TX00D1390	75.5	27	60.2	26.5	30.7	0.4	1.6	4.8	8.5	12.7	23.6	47.7
KARL 92	75.1	28	59.5	24.3	31.0	0.4	6.8	1.1	9.7	14.4	27.9	63.0
KS03HW36	74.9	29	60.8	29.3	36.0	0.7	1.4	0.0	9.7	12.9	25.1	55.8
TX01D3232	74.5	30	57.4	24.8	29.3	0.2	2.8	4.1	8.8	13.4	26.3	53.4
KS03HW83	71.4	31	58.5	27.7	34.8	3.2	1.8	1.4	8.5	13.1	25.4	55.2
KS99011-1-~27	69.6	32	58.1	24.0	29.5	0.2	3.2	0.4	9.8	14.5	29.4	64.6
GRAND MEAN	85.2		59.2	26.7	31.5	0.5	2.5	1.5	9.2	13.0	24.9	50.9
CV %	8.0		0.7	2.9	3.3	168.8	28.3	54.1	7.7	4.1	7.3	9.8
LSD (0.05)	6.7		0.4	0.9	1.2	0.9	0.9	0.8	1.2	0.5	1.8	4.9

1 Belgian Lodging = Area x Intensity x 0.2. Area is rated on a scale from 1 (plot unaffected) to 10 (entire plot affected). Intensity is rated on a scale from 1 (plants standing upright) to 5 (plants lying flat on the ground).

Grain samples from the Warsaw test were evaluated for milling and baking quality by Mennel Milling Company (Table 2) and the USDA-ARS Hard Wheat Quality Lab (Table 3). The HRW wheat cultivar Karl 92 was considered as the quality standard since it has excellent milling and baking quality. On the basis of data provide by Mennel, milling and baking quality of the HRW wheat line KS 00F5-58-3 was equal to that of Karl 92. Soissons, Lakin, 92PAN2#26, and

TX99D4478 also had overall good milling and baking quality with loaf volumes greater than 2600 cc.

Table 2. Milling and Baking Quality of 2006 Bread Wheat Preliminary and Elite Tests, Conducted by: Mennel Milling Co.

VARIETY	Test Weight	Falling No.	Grain Protein	Flour Yield	Flour Ash	Flour Protein	Water Absorb	Mix Time-Peak	Mix Tol. Index	Mixing Stability	Loaf Vol.	Loaf Score	Crumb Score	Overall Score
	>58	>250	≥ 12%	>68%		≥10.5%	≥ 55%	5 - 8	25-45	≥ 10	>2500	5 - 6	5 - 6	5 - 6
PIONEER 26R15	62.2	445	11.0	70.6	0.42	10.1	52.8	2.5	28	18.9	2620	6.2	5.0	5.0
RENWOOD 3260	63.6	347	11.3	68.9	0.39	10.8	54.4	3.0	22	17.3	2550	5.5	4.0	4.5
TRIBUTE	65.6	406	10.7	69.5	0.42	9.5	56.9	1.9	50	5.6	2320	3.2	4.0	3.5
KARL 92 = STD	**62.1**	**336**	**13.8**	**68.2**	**0.50**	**12.7**	**62.1**	**4.0**	**28**	**9.4**	**2760**	**7.6**	**4.5**	**5.0**
SOISSONS	62.4	410	11.4	72.9	0.42	10.3	56.6	2.3	37	11.1	2620	6.2	4.5	5.0
Lakin	64.2	297	12.5	69.1	0.45	11.6	60.9	2.4	31	8.0	2670	6.7	4.5	4.5
TAM 110	65.6	379	11.7	70.3	0.51	10.8	63.8	3.9	35	8.1	2400	4.0	5.0	5.0
TAM 302	61.9	350	11.9	69.6	0.46	10.5	61.3	3.9	48	6.8	2500	5.0	4.0	4.5
CULPEPPER	63.0	437	11.4	68.6	0.50	10.0	63.7	2.2	43	6.3	2480	4.8	4.5	4.5
92PAN2#26	**61.5**	**426**	**12.3**	**70.4**	**0.45**	**11.1**	**63.4**	**2.4**	**54**	**6.1**	**2640**	**5.4**	**4.0**	**4.5**
KS 00F5-58-3	**63.6**	**409**	**12.0**	**69.1**	**0.45**	**11.1**	**62.0**	**2.8**	**36**	**8.5**	**2680**	**5.8**	**5.5**	**5.5**
KS00F5--20-3-2	63.4	422	12.3	69.3	0.46	11.2	65.7	2.8	50	6.3	2400	3.0	4.5	3.5
KS970085-9-15	63.0	453	10.0	65.9	0.45	9.1	57.4	3.2	64	5.4	2460	4.6	4.0	3.0
KS970085-9-19	62.6	357	9.0	66.7	0.45	8.9	56.9	2.0	43	6.2	2360	3.6	4.0	2.5
SX1432W	62.3	370	11.0	68.7	0.51	10.2	60.3	2.3	38	9.7	2530	5.3	4.5	5.0
TX99D4478	63.2	431	12.4	69.7	0.49	10.8	61.6	3.0	42	7.9	2600	6.0	4.5	5.0
TX02D5406	63.0	453	10.4	68.6	0.42	9.5	56.0	2.7	60	4.3	2300	3.0	3.0	2.0
TX02D6833	61.4	406	11.6	66.8	0.40	9.6	57.7	3.2	79	3.9	2300	3.0	3.0	2.0
U3960-3R-3-11-6	62.0	420	11.6	65.7	0.51	10.1	61.2	3.2	26	10.3	2460	4.6	5.0	4.5
VA05HRW-3	62.5	385	11.6	66.6	0.43	9.5	60.2	1.4	80	4.1	2610	6.1	4.0	2.5
VA05HRW-9	**62.2**	**446**	**10.6**	**70.8**	**0.51**	**9.9**	**60.2**	**2.0**	**48**	**6.3**	**2550**	**4.5**	**5.0**	**5.0**
VA05HRW-24	60.9	270	13.3	67.0	0.44	11.8	57.3	3.3	66	6.0	2280	2.8	2.0	1.0
VA05HRW-31	61.5	362	12.1	64.3	0.43	10.8	57.2	4.5	58	6.4	2540	5.4	3.5	3.0
VA05HRW-34	62.3	333	10.8	62.8	0.42	9.7	59.4	1.8	55	5.5	2380	2.8	4.0	3.5
VA05HRW-38	62.6	353	11.8	65.2	0.43	10.4	59.8	2.2	46	6.9	2420	3.2	4.0	4.0
VAK05HRW-53	63.1	413	11.6	66.7	0.51	10.1	65.9	2.7	44	8.2	2610	5.1	3.5	4.0
VAK05HRW-54	62.3	412	11.9	67.6	0.55	10.8	65.5	2.2	63	4.9	2500	4.0	5.0	4.0
C 1383	62.5	414	10.9	68.9	0.50	10.0	64.5	2.0	68	2.7	2400	3.0	4.0	3.5
C 4116 A	62.6	308	11.3	69.3	0.49	10.0	65.8	1.8	80	2.5	2400	3.0	5.0	4.0
D 1125	59.9	306	11.3	69.5	0.46	10.0	63.6	3.0	86	3.1	2360	2.6	3.5	1.0

Preliminary Experimental Bread Wheat Test

Among the first 65 hard wheat lines selected in the breeding program at Virginia Tech, 15 HRW and 1 HWW wheat lines were selected for further testing and were evaluated in replicated yield tests at two locations in 2006. Grain yields of the best lines were similar to those of the widely grown SRW wheat Tribute (Table 4). Grain samples from the Warsaw test were evaluated for milling and baking quality by Mennel Milling Company (Table 2) and the USDA-ARS Hard Wheat Quality Lab (Table 3). The lines VA05HRW-9, VAK05HRW-53, and VAK05HRW-54 had the best overall quality among the experimental lines.

Table 3. Milling and Baking Quality of 2006 Bread Wheat Preliminary and Elite Tests, Conducted by: USDA-ARS Hard Wheat Quality Lab.

VARIETY	Test Weight	1000 KWT	Kernel Hard-ness	Grain Hard-ness	Grain Class	Grain Protein	Flour Yield	Flour Ash	Flour Protein	Water Absorb	Mix Time	Mix Tol.	Bake Mix Time	Loaf Vol.	Crumb Score	Crumb Color
PIONEER 26R15	61.6	36.8	12	15	SOFT	11.1	72.8	0.38	10.2	59.9	3.51	4	4.68	850	3.8	dull
RENWOOD 3260	63.2	35.6	17	19	SOFT	11.7	71.3	0.38	10.4	60.2	3.42	3	3.63	835	3.5	dull
TRIBUTE	65.2	41.9	32	27	SOFT	10.7	73.1	0.42	9.5	58.7	1.91	3	3.48	720	2.0	dull
KARL 92 = STD	**61.5**	**40.2**	**52**	**55**	**HARD**	**13.3**	**70.6**	**0.45**	**12.3**	**63.5**	**5.88**	**5**	**6.50**	**845**	**3.2**	**creamy**
SOISSONS	60.2	41.5	49	53	MIXED	11.5	76.0	0.47	10.3	60.1	3.57	5	4.36	815	3.5	dull
Lakin	63.6	41.9	59	59	HARD	11.7	72.7	0.44	11.1	61.4	3.01	3	3.35	805	3.0	creamy
TAM 110	63.4	48.3	58	69	HARD	11.8	73.0	0.45	10.7	60.7	3.05	4	3.57	770	2.2	yellow
TAM 302	61.3	40.8	59	59	HARD	11.5	71.7	0.45	10.4	60.3	2.44	3	3.45	785	3.0	dull
CULPEPPER	62.3	45.0	57	55	HARD	11.1	71.8	0.48	10.4	60.2	2.92	4	5.04	700	1.8	dull
92PAN2#26	**61.0**	**42.0**	**58**	**61**	**HARD**	**11.9**	**73.9**	**0.47**	**11.0**	**61.3**	**2.32**	**3**	**3.31**	**780**	**3.0**	**dull**
KS 00F5-58-3	**63.5**	**37.0**	**61**	**58**	**HARD**	**12.5**	**71.5**	**0.44**	**11.4**	**61.9**	**5.10**	**5**	**6.26**	**835**	**2.0**	**creamy**
KS00F5--20-3-2	63.2	43.7	67	72	HARD	12.2	74.3	0.47	11.0	62.3	1.76	3	3.30	770	3.2	dull
KS970085-9-15	62.5	42.2	10	18	SOFT	10.5	67.9	0.44	9.3	58.3	1.84	2	2.01	735	3.0	creamy
KS970085-9-19	62.0	40.5	12	15	SOFT	9.8	68.0	0.43	8.8	57.6	1.63	2	1.94	745	2.5	creamy
SX1432W	61.6	37.5	62	48	HARD	11.0	72.2	0.55	9.8	59.3	2.78	4	4.73	765	3.5	slight yellow
TX99D4478	62.7	47.2	54	64	HARD	12.1	73.4	0.40	11.1	61.4	3.34	4	4.01	775	2.5	yellow
TX02D5406	62.5	39.0	14	19	SOFT	10.8	71.0	0.46	9.3	58.5	1.53	1	1.70	800	2.0	creamy
TX02D6833	60.8	40.6	12	17	SOFT	11.1	68.3	0.45	9.7	59.1	1.73	1	1.73	785	2.0	yellow
U3960-3R-3-11-6	61.4	45.4	60	46	HARD	11.3	70.2	0.52	10.1	62.5	2.21	4	3.26	800	3.0	yellow
VA05HRW-3	61.6	43.1	17	20	SOFT	10.8	73.2	0.50	10.0	58.2	2.46	2	2.93	760	1.8	yellow
VA05HRW-9	61.5	38.8	60	59	HARD	10.8	74.1	0.51	9.7	59.9	2.51	4	3.95	760	3.0	yellow
VA05HRW-24	60.3	39.9	4	18	SOFT	13.2	72.2	0.49	12.2	63.9	2.50	0	2.25	840	1.8	slight yellow
VA05HRW-31	61.0	37.7	4	8	SOFT	12.3	70.4	0.47	11.2	62.3	2.95	3	3.98	893	3.3	slight yellow
VA05HRW-34	61.8	40.8	24	11	SOFT	10.6	70.7	0.50	9.5	59.3	3.48	5	5.91	765	2.0	slight yellow
VA05HRW-38	62.0	39.4	31	20	SOFT	11.5	71.3	0.48	10.1	60.3	4.90	6	6.25	790	2.5	gray
VAK05HRW-53	62.6	32.7	27	18	SOFT	11.5	71.9	0.59	10.4	59.7	3.12	3	3.92	800	3.0	slight yellow
VAK05HRW-54	61.8	36.5	52	39	MIXED	11.9	69.4	0.54	10.9	61.1	3.37	4	5.43	780	2.5	slight yellow
C 1383	62.2	53.0	66	60	HARD	11.1	74.6	0.53	9.9	60.9	4.41	6	6.84	675	2.5	dull
C 4116 A	61.9	52.0	68	64	HARD	11.0	74.0	0.48	9.9	61.5	3.09	4	4.87	710	2.0	yellow
D 1125	59.2	50.7	57	62	HARD	11.0	74.5	0.46	10.1	59.7	1.82	2	1.92	670	1.5	yellow
Mean	62.0	41.7	40.6	40.4		11.4	72.0	0.5	10.3	60.5	3.0	3.4	4.0	778.6	2.6	
Std	1.2	4.8	22.4	21.5		0.8	2.0	0.0	0.8	1.6	1.1	1.4	1.5	51.7	0.6	
C.V.	1.9	11.6	55.2	53.1		6.8	2.8	10.2	8.0	2.6	36.1	42.0	37.3	6.6	24.2	
Min	59.2	32.7	4.2	8.5		9.8	67.9	0.4	8.8	57.6	1.5	0.0	1.7	670.0	1.5	
Max	65.2	53.0	67.9	72.0		13.3	76.0	0.6	12.3	63.9	5.9	6.0	6.8	893.0	3.8	

Table 4. Agronomic Data for 2006 Preliminary Bread Wheat Test.

LINE	Yield Bu/a	Yield Rank	Test Weight lb/bu	Heading Date (Mar 31+)	Height (in)	Lodging (0.2-10)[1]	Leaf Rust (0-9)	Powdery Mildew (0-9)	Early Height (3-27) Inches	Protein %	Gluten %	Zeleny
Locations	BB WR		BB WR	BB WR	BB WR	BB WR	WR	BB WR	WR	BB WR	BB WR	BB WR
TRIBUTE	102.0	1	61.3	27.0	29.3	0.3	2.0	0.0	8.3	12.5	23.9	45.1
VA05HRW-38	99.0	2	59.0	25.2	30.7	0.2	5.3	1.3	9.8	13.3	26.5	51.1
VA05HRW-9	97.5	3	58.4	25.7	30.0	0.2	2.7	1.8	9.0	12.2	22.8	41.9
VA05HRW-3	97.2	4	58.6	23.2	30.0	0.4	3.0	0.3	10.8	13.7	26.8	55.0
RENWOOD 3260	96.6	5	60.2	24.5	31.8	0.4	2.0	0.2	9.7	13.7	27.2	53.0
VA05HRW-34	95.9	6	58.7	24.5	30.0	0.2	3.3	1.2	11.2	12.9	25.5	46.6
SOISSONS	94.3	7	58.4	30.7	30.5	0.2	4.7	0.3	8.3	12.6	21.9	44.3
VA05HRW-31	90.9	8	58.1	26.0	29.5	0.2	2.3	0.5	9.7	14.1	28.1	52.5
VAK05HRW-53	89.5	9	58.8	26.7	29.8	0.9	1.7	0.0	6.8	13.7	27.0	54.2
VA05HRW-8	88.5	10	57.7	27.7	28.8	0.2	4.7	4.2	8.3	13.0	26.2	52.1
VA05HRW-22	88.4	11	58.0	32.0	35.7	0.2	4.3	2.7	8.8	13.1	26.3	46.9
NX03Y2395	88.4	12	59.1	23.3	31.2	0.4	4.3	1.7	9.0	14.0	25.6	59.9
VA05HRW-21- (Baytan)	88.2	13	60.3	29.2	30.3	0.2	7.0	2.3	8.7	13.9	26.5	57.7
VAK05HRW-54	88.1	14	57.5	25.3	30.3	0.4	2.7	0.0	8.2	14.3	27.7	61.4
VA05HRW-23	88.0	15	57.5	31.5	36.3	0.2	5.0	3.0	9.5	12.7	25.3	44.3
VA05HRW-10	87.3	16	58.0	27.5	28.0	0.2	6.3	1.5	9.2	13.5	26.7	53.0
LAKIN	86.7	17	60.2	27.0	34.0	0.4	7.3	2.5	8.8	13.1	26.1	57.7
VAK05HRW-55	86.3	18	58.9	26.3	28.2	0.5	3.7	0.0	8.3	13.2	26.9	53.2
VA05HRW-24	85.9	19	58.1	24.7	33.0	0.2	2.7	0.8	10.8	15.5	31.6	62.4
VA05HRW-21	81.7	20	60.2	29.3	30.8	0.2	8.7	3.2	8.2	13.8	26.4	56.5
VA05HRW-15	80.4	21	60.9	28.3	33.8	0.2	3.0	1.5	10.2	14.5	28.5	62.8
TAM 110	76.5	22	58.9	23.0	33.5	1.2	8.3	0.0	10.3	13.5	26.4	54.5
VAK05HWW-66	75.1	23	59.7	27.3	31.3	0.2	3.3	2.8	8.8	15.0	30.6	67.5
KARL 92	72.9	24	58.7	25.0	29.7	0.4	8.3	1.3	8.8	15.2	29.8	68.9
IKE	70.3	25	59.8	29.2	35.3	0.8	4.3	3.2	7.7	13.9	29.4	61.3
GRAND MEAN	87.8		59.0	26.8	31.3	0.4	4.4	1.5	9.1	13.6	26.8	54.6
CV %	6.8		0.6	2.4	3.2	58.9	22.0	50.0	8.1	2.6	4.2	5.4
LSD (0.05)	6.8		0.4	0.8	1.2	0.2	1.6	0.8	1.2	0.4	1.3	3.4

New Bread Wheat Lines Evaluated in 2006 Observation Yield Tests

Single yield plot tests of 113 new bread wheat lines developed at Virginia Tech were evaluated for agronomic performance in field tests at Blacksburg and Warsaw, VA. Grain yields of the SRW wheat checks Renwood 3260 and Tribute averaged 95 and 100 bu/ac. The French cultivar Soissons had an average yield of 86 bu/ac, and the HRW wheat checks Karl 92 and Lakin had average yields of 77 and 84 bu/ac. Twenty four of the 113 HRW experimental lines had grain yields ranging from 95 to 105 bu/ac (Table 5).

Table 5. Agronomic Data for 2006 Bread Wheat Observation Tests.

LINE	PEDIGREE	Yield bu/a	Yield rank	TWT	HD	HT	Lodg-ing	LR (0-9)	PM (0-9)	Protein	Gluten	Zeleny
VA06HRW-2	VA97W-469 / HEYNE	89.2	72	60.3	24.5	31.5	0.3	2.0	0.0	13.5	26.4	47.4
VA06HRW-5	PIONEER 2643 / 92PIN#109	92.2	39	59.6	25.5	31.0	0.2	2.0	2.0	13.7	27.7	50.6
VA06HRW-70	92PIN#135 / PIONEER 2643,F6	97.0	14	59.7	27.0	32.0	0.2	3.0	0.5	13.0	25.1	47.9
SOISSONS	EUROPEAN BREAD WHEAT CHECK	82.8	113	58.8	31.5	30.0	0.2	5.0	0.0	13.0	23.0	46.0
VA06HRW-19	SOISSONS / 92PAN1 #29	96.7	15	59.8	26.5	30.0	0.2	2.0	1.0	13.6	25.3	51.1
VA06HRW-31	SOISSONS / 92PIN#107	91.8	44	60.5	26.0	31.0	0.2	5.0	1.5	13.5	24.1	50.1
VA06HRW-59	92PIN#109 / SOISSONS,F6	96.2	18	57.8	28.0	31.0	0.2	7.0	2.0	12.5	24.1	45.6
RENWOOD 3260	SRW-WHEAT CHECK	97.8	12	60.3	25.0	33.5	1.4	2.0	0.0	13.6	26.8	51.6
VA06HRW-49	92PAN1 #33 / RENWOOD 3260"S"	98.3	9	58.9	26.0	33.0	0.2	1.0	0.5	14.1	28.2	58.4
TAM 110	HRW WHEAT CHECK	76.0	137	59.5	25.0	33.5	1.6	7.0	0.0	13.5	26.2	55.6
VA06HRW-66	92PIN#109 / 92PAN1 #33	91.9	43	58.5	28.5	33.5	0.2	5.0	2.0	12.9	24.2	47.8
VA06HRW-77	92PIN#135 / RECITAL	91.6	46	60.9	25.0	30.0	0.2	5.0	3.0	13.4	24.9	51.1
VA06HRW-87	TREMIE/VA96W-391//92PAN1#29,F6	96.5	17	58.0	27.5	33.5	0.2	2.0	0.0	12.7	26.1	47.1
VA06HRW-93	GENESIS / VA96W-391 // RECITAL	90.8	55	57.9	25.0	29.5	0.2	3.0	0.0	14.0	26.8	56.7
VA06HRW-96	GENESIS / VA96W-391 // 92PAN1#29	91.5	48	58.6	27.0	32.0	1.9	4.0	0.0	13.7	26.7	58.8
VA06HRW-103	AMELIO/ PION 26R61// 92PIN#135	95.0	25	59.2	31.0	31.5	0.2	2.0	0.5	13.5	26.6	53.8
VA06HRW-112	92PIN#135 // PION 2643 / TRIBUTE	95.6	21	59.4	26.5	30.5	0.2	2.0	1.0	12.9	24.6	41.9
TRIBUTE	SRW-WHEAT CHECK	93.5	30	62.2	28.0	29.0	0.2	1.0	0.0	13.0	25.5	50.7
VAK06HRW-118	X940748-2-4 / TX97V4311	93.6	28	58.5	25.0	34.0	0.2	3.0	0.0	13.5	26.9	53.6
VAK06HRW-120	HONDO / HEYNE	93.3	32	60.1	26.0	32.0	0.2	2.0	0.0	14.5	29.2	61.8

Milling and baking quality analyses of selected bread wheat observation lines were performed by Mennel Milling Company using a grain composite derived from both locations. Fifteen experimental lines having grain yields above 90 bu/ac had grain protein concentrations ranging from 11.5 to 12.8%, loaf volumes ranging from 2500 to 2780 cc, and overall quality scores ranging from 4.5 to 5.5 (Table 6). These new HRW wheat lines that have both good yield and end use quality are very exciting and offer real potential to producers, millers, and bakers.

Table 6. Milling and Baking Quality of 2006 Bread Wheat Observation Tests.

LINE	PEDIGREE	Yield bu/a	Grain Protein %	Flour Protein %	Flour Yield %	Flour Water Abs %	Dough Mixing Stability	Dough Mixing Tol	Loaf Volume	Loaf Score	Crumb Grain Score	Over All Score
VA06HRW-2	VA97W-469 / HEYNE	89.2	12.2	11.2	72.8	55.6	13.4	20	2570	5.7	4.5	4.5
VA06HRW-5	PIONEER 2643 / 92PIN#109	92.2	12.0	10.6	67.6	54.0	12.3	22	2500	5.0	5.0	4.5
VA06HRW-70	92PIN#135 / PIONEER 2643,F6	97.0	11.6	10.0	73.6	52.5	9.5	31	2700	7.0	5.0	5.0
SOISSONS	EUROPEAN BREAD WHEAT CHECK	82.8	11.9	10.8	70.4	55.1	12.6	32	2440	4.4	4.0	4.0
VA06HRW-19	SOISSONS / 92PAN1 #29	96.7	12.5	11.3	70.1	57.6	18.2	22	2650	6.5	4.5	5.0
VA06HRW-31	SOISSONS / 92PIN#107	91.8	12.0	11.3	70.5	55.4	18.8	25	2770	7.7	4.5	5.0
VA06HRW-59	92PIN#109 / SOISSONS,F6	96.2	11.5	9.9	69.4	58.0	9.4	42	2590	5.9	5.0	4.5
RENWOOD 3260	SRW-WHEAT CHECK	97.8	12.3	10.9	70.2	54.7	11.2	37	2490	4.9	4.0	3.0
VA06HRW-49	92PAN1 #33 / RENWOOD 3260"S"	98.3	11.8	11.3	65.4	58.3	10.6	29	2590	5.9	5.0	4.5
TAM 110	HRW WHEAT CHECK	76.0	12.2	10.9	69.9	60.9	6.2	48	2500	5.0	5.0	3.5
VA06HRW-66	92PIN#109 / 92PAN1 #33	91.9	12.0	10.8	69.8	56.5	7.6	45	2650	6.5	5.0	5.0
VA06HRW-77	92PIN#135 / RECITAL	91.6	12.3	10.0	65.3	56.9	15.2	16	2760	7.6	4.5	5.5
VA06HRW-87	TREMIE/VA96W-391//92PAN1#29,F6	96.5	11.7	10.7	67.9	58.8	7.5	45	2650	6.5	4.5	5.0
VA06HRW-93	GENESIS / VA96W-391 // RECITAL	90.8	12.8	12.0	67.6	57.0	11.5	31	2780	7.8	4.5	5.5
VA06HRW-96	GENESIS / VA96W-391 // 92PAN1#29	91.5	12.3	11.3	66.6	58.1	8.3	34	2720	7.2	4.5	5.0
VA06HRW-103	AMELIO/ PION 26R61// 92PIN#135	95.0	12.2	10.4	66.5	53.7	10.8	39	2640	6.4	4.5	4.5
VA06HRW-112	92PIN#135 // PION 2643 / TRIBUTE	95.6	11.8	10.5	69.6	54.4	9.1	42	2680	6.8	4.0	5.0
TRIBUTE	SRW-WHEAT CHECK	93.5	12.2	10.3	70.3	55.4	9.7	38	2310	3.1	4.0	4.0
VAK06HRW-118	X940748-2-4 / TX97V4311	93.6	12.6	10.7	68.7	59.5	12.4	25	2590	5.9	4.0	4.5
VAK06HRW-120	HONDO / HEYNE	93.3	12.8	11.3	66.7	60.2	14.3	22	2620	6.2	4.5	4.5
KARL 92	Quality Standard	77.0	12.8	11.7	67.6	60.7	9.4	37	2720	7.2	5.0	5.5

Bread Wheat Breeding & Population Advancement

In fall 2006, we planted 136 bread wheat breeding populations and 106 new F_1 populations derived from crosses made among bread wheat and/or strong gluten SRW wheat lines in spring 2006. More than 5400 headrows (progeny derived from a single wheat head and planted in a 4 ft row) derived from bread wheat populations are currently being evaluated in the field at Warsaw, VA from which selected headrows will be harvested and planted in observation yield plots in fall 2007. Currently 160 new hard wheat lines selected from our headrow nursery in 2006 are being evaluated in observation yield nurseries at two locations in 2007. In replicated yield trials, 54 bread wheat lines are being evaluated at three locations in our Bread Wheat Elite Test, 48 wheat lines in the Uniform Regional Bread Wheat Nursery and 42 HRW wheat lines developed at Virginia Tech are being evaluated in our Bread Wheat Preliminary Nursery at two locations in 2007. During spring 2007, 203 new crosses were made among bread wheat and/or strong gluten SRW wheat lines. The program continues to evaluate new bread wheat lines including 12 new HRW wheat lines from KSU and 11 new French lines from Serasem that are currently being evaluated in yield tests at Warsaw, VA. Many of these lines are used as parents in our crossing program.

Project Component: Breeding & Development of Hulless Barley Varieties

This project was initiated to develop hulless winter barley (*Hordeum vulgare* L.) as an improved feed crop in the mid-Atlantic and southeastern regions. Winter barley is an excellent crop in rotation with soybean (*Glycine max* L.). However, production of winter barley has decreased since 1996 mainly due to low market prices, even though the mid-Atlantic and southeastern regions are considered feed grain deficient areas. Therefore, barley varieties with value-added traits need to be developed in order to revive production in these regions.

The primary objective of this project is to develop barley varieties with greater marketability in both domestic and foreign markets and, thereby, make barley an economical cash crop. The proposed research is designed to improve the end use value of barley by developing hulless varieties having lower concentrations of fiber and phytic acid, and higher metabolizable energy. This transformation should bring the feed value of barley closer to that of corn or wheat. Potential use of barley in ethanol production necessitates the development of high-energy hulless varieties with low fiber and beta glucan concentrations. Realization of new markets for barley such as this one would greatly enhance value of this crop.

The second objective, which is quite converse to the first in end results, is to develop hulless barley varieties that would meet the needs of an increasing demand for healthy food commodities. Waxy hulless barley can have beta glucan content as high as 12%. Such barley would have more-soluble fiber combined with high beta glucan concentration, both of which have been shown to be important in reducing blood cholesterol levels. Hulless barley also has phytochemicals that behave as antioxidants, which are often associated with cancer prevention. Barley flour or beta glucan potentially could be used in the production of health foods and dietary supplements.

Hulless Barley Discussion, EVAREC.

The Virginia Tech Breeding Program has again completed another season (2005-2006) of the hulless barley project. Rapid progress is being made by the program in developing new hulless barley varieties for production in the mid Atlantic region. Emphasis will be placed on improving grain yields, end use quality, and resistance to net blotch and scab. This season (2006-2007), we will continue to evaluate new lines for potential release. Meanwhile, we are pleased to report release of ‘Eve’ (tested as VA01H-68) as the second winter hulless barley developed by the Virginia Tech barley breeding program. Advance hulless lines VA03H-61 and VA04H-53 are also being considered for potential release. We will continue to develop and evaluate new hulless lines derived from crosses made between hulled cultivars and breeding lines with a number of our

outstanding hulless lines. Other breeding populations derived from crosses with hulless lines introduced from various sources (USDA World Collection, CIMMYT in Mexico, Austria, Canada, Australia and France) are being advanced in the program. This past spring (2007), we made over 450 crosses in the greenhouse comprised of hulless barley parents. This season (2006-2007), we planted F_1 progeny from 240 crosses made in 2006, and F_2 progeny from 173 crosses made in 2005. The hulless lines that are in the advance stages of testing show a great deal of promise with respect to agronomic performance. We have developed hulless lines that yield 5-18 Bu/ac higher than initial hulless lines developed in South Carolina and 2-8 Bu/ac more than Doyce. Many lines have improved straw strength and grain plumpness and have better resistance to diseases (eg. leaf rust, powdery mildew, net blotch, and scald).

Performance data of hulless entries in the Virginia Tech State Barley Trial conducted at seven locations in 2005-2006 are presented in Table 1. The best hulless experimental line VA04H-53 yielded 2 Bu/ac more than Doyce, 11 Bu/ac more than the hulless check H-585 (Hulless line from South Carolina) and 6 Bu/ac higher than the test average. Average grain yield of VA03H-61 (88 Bu/ac) was similar to that of Doyce and 9 Bu/ac higher than that of the hulless check H-585. VA04H-61 had the highest average test weight (60.6 Lbs/bu), which was significantly higher than that of Doyce (56.9 Lbs/bu). Average grain yield of Eve (85 Bu/ac) was 6 Bu/ac higher than H-585. In addition, Eve is two or more days earlier heading than Doyce. Elite hulless lines VA03H-61 and VA04H-53 are being considered for potential release.

Table 1. Summary of performance of hulless entries in the Virginia Tech Barley Test Over Locations, 2006.

Hulless Lines	Yield (Bu/a)		Test Weight (Lb/bu)		Date Headed (Mar31+)		Height (In)		Lodging (0.2-10)		Net Blotch (0-9)		Leaf Rust (0-9)		Leaf Spot (0-9)		Early Height (In)	
	(7)		(7)		(4)		(4)		(6)		(1)		(3)		(2)		(2)	
VA04H-53	90	+	58.9	+	20	+	35	+	3.0	+	2		4	+	1	-	7.2	
Doyce	88	+	56.9	-	16	-	32	-	2.8		3	+	1	-	4	+	8.6	+
VA03H-61	88	+	60.6	+	20	+	33		1.1	-	2		2	-	2	-	4.8	-
VA01H-125	86		58.4		14	-	27	-	2.3		3	+	4	+	5	+	7.5	
Eve	85		58.6		14	-	33		2.2		3	+	2	-	3		9.0	+
VA03H-100	85		59.0	+	18	+	38	+	2.1		2		5	+	2	-	6.9	
VA03H-64	83		58.4		18	+	36	+	2.3		2		5	+	2	-	6.8	
VA01H-1	82		57.9	-	16	-	32	-	1.1	-	3	+	3		4	+	8.5	
VA04H-59	82		57.9	-	17		38	+	2.6		2		3		1	-	7.6	
VA04H-111	81	-	58.7		17		34	+	2.2		1	-	1	-	2	-	9.4	+
VA04H-25	79	-	60.1	+	16	-	34	+	1.2	-	1	-	2	-	2	-	8.7	+
H-585	79	-	57.5	-	13	-	33		2.0		3	+	4	+	4	+	8.4	
VA03H-58	79	-	59.6	+	19	+	30	-	4.6	+	2		3		3		5.5	-
Average	84		58.6		17		33		2.3		2		3		3		7.6	
C.V.	8		1.0		4		4		---		---		---		---		13.5	
LSD (0.05)	3		0.3		1		1		0.7		1		1		1		1.0	

Released cultivars are shown in bold print.
The number in parentheses below column headings indicates the number of locations on which data are based.
Varieties are ordered by descending yield averages.
A plus or minus sign indicates a performance significantly above or below the test average
Belgian Lodging Scale = Area X Intensity X 0.2. Area = 1-10, where 1 is barley unaffected and 10 is entire plot affected and Intensity = 1-5, where 1 is barley standing upright and 5 is barley totally flat.
The 0-9 ratings indicate a genotype's response to disease, where 0 = highly resistant and 9 = highly susceptible.

Two year average (2005 and 2006) performance data of hulless entries evaluated in Virginia Tech's official Barley variety Trial are presented in Table 2. Doyce had the highest average grain yield (83 Bu/ac), which was 7 Bu/ac higher than that of the hulless check H-585 (76 Bu/ac). Eve had an average grain yield (83 Bu/ac) that was similar to that of Doyce. On the other hand, Eve had the highest average test weight (58.5 Lbs/bu).

Table 2. Two-year average summary of performance of hulless entries in the Virginia Tech Barley Tests, 2005 and 2006 harvests.

Hulless Lines	Yield (Bu/a)		Test Weight (Lb/bu)		Date Headed (Mar31+)		Height (In)		Lodging (0.2-10)		Net Blotch (0-9)		Leaf Rust (0-9)		Leaf Spot (0-9)		Leaf Septoria (0-9)		Early Height (In)	Winter Survival (%)	
	(10)		(12)		(7)		(7)		(10)		(2)		(5)		(3)		(1)		(2)	(1)	
Doyce	83	+	56.1	-	20	+	33	+	2.6	+	4		1	-	4		0		8.6	16	-
Eve	83	+	58.5	+	18		34	+	1.7		4		2		3	-	0		9.0	64	
VA01H-125	81		57.7	+	18		28	-	1.7		5	+	3	+	5	+	0		7.5	91	+
VA01H-1	79		57.5		20	+	33	+	0.8	-	4		2		4		0		8.5	86	+
H-585	76	-	56.9	-	17	-	34	+	1.5		4		4	+	4		0		8.4	89	+
Average	80		57.4		18		32		1.6		4		2		4		0.1		8.4	69	
C.V.	11		1.3		4		5		---		---		---		---		---		11.4	16	
LSD (0.05)	3		0.3		0.4		1		0.4		1		1		1		0.5		1	17	

Released cultivars are shown in bold print.
The number in parentheses below column headings indicates the number of locations on which data are based.
Varieties are ordered by descending yield averages.
A plus or minus sign indicates a performance significantly above or below the test average
Belgian Lodging Scale = Area X Intensity X 0.2. Area = 1-10, where 1 is barley unaffected and 10 is entire plot affected and Intensity = 1-5, where 1 is barley standing upright and 5 is barley totally flat.
The 0-9 ratings indicate a genotype's response to disease, where 0 = highly resistant and 9 = highly susceptible.

Three year average (2004-2006) performance data of hulless barley entries evaluated in Virginia Tech's official Barley variety Trial are presented in Table 3. Doyce had the highest average grain yield (83 Bu/ac), which was significantly higher than that of the hulless check H-585 (74 Bu/ac). Eve had an average grain yield (81 Bu/ac) that was 2 Bu/ac less than that of Doyce and 7 Bu/ac higher than that of the hulless check H-585. While average grain yield of Eve was 2 Bu/ac less than that of Doyce, it had test weight that was significantly higher (2.2 Lbs/bu) than that of Doyce. Breeder seed for Eve is being developed this season (2006-2007) and will be multiplied by the Virginia Crop Improvement Foundation seed farm in the fall of 2007.

Table 3. Three-year average summary of performance of hulless entries in the Virginia Tech Barley Tests, 2004, 2005 and 2006 harvests.

Hulless Lines	Yield (Bu/a)		Test Weight (Lb/bu)		Date Headed (Mar31+)		Height (In)		Lodging (0.2-10)		Net Blotch (0-9)		Leaf Rust (0-9)		Leaf Spot (0-9)		Leaf Septoria (0-9)		Early Height (In)	Winter Survival (%)	
	(13)		(15)		(10)		(10)		(13)		(3)		(6)		(3)		(1)		(2)	(1)	
Doyce	83	+	55.9	-	21	+	33	+	2.1	+	5		1	-	4		0		8.6	16	-
Eve	81		58.1	+	19		34	+	1.4		4	-	2	-	3	-	0		9.0	64	
VA01H-125	76	-	57.5	+	19		27	-	1.4		5		4	+	5	+	0		7.5	91	+
H-585	74	-	56.5	-	19		34	+	1.2	-	5		4	+	4		0		8.4	89	+
Average	79		57.0		19		32		1.5		5		3		4		0		8.4	65	
C.V.	10		1.4		4		5		---		---		---		---		---		12.3	18	
LSD (0.05)	3		0.3		0.3		1		0.3		1		1		1		0		1.1	19	

Released cultivars are shown in bold print.
The number in parentheses below column headings indicates the number of locations on which data are based.
Varieties are ordered by descending yield averages.
A plus or minus sign indicates a performance significantly above or below the test average
Belgian Lodging Scale = Area X Intensity X 0.2. Area = 1-10, where 1 is barley unaffected and 10 is entire plot affected and Intensity = 1-5, where 1 is barley standing upright and 5 is barley totally flat.
The 0-9 ratings indicate a genotype's response to disease, where 0 = highly resistant and 9 = highly susceptible.

Performance of advanced hulless lines in tests conducted at three locations in Virginia in 2005-2006 is summarized in Table 4. The best hulless experimental line VA03H-61 yielded 8.4 Bu/ac more than Doyce and 14.4 Bu/ac higher than the hulless check H-585. Eve was among the top yielding at 86.2 Bu/ac. In addition, Eve and 10 other hulless experimental lines had grain yield that were 1-7 Bu/ac higher than that of Doyce. Eve and the 10 hulless experimental lines had average grain yields, ranging from 88.2 (VA04H-113) to 82.1 (VA04H-95) Bu/ac. Among 25 Advance hulless lines, all except for VA04H-35 (57.4 Lbs/bu) had average test weights that were higher than that of Doyce (57.6 Lbs/bu). Among all 25 hulless lines, VA04H-25 had the highest mean test weight (61.1 Lbs/bu), which was significantly higher than that of Doyce (57.6 Lb/bu).

Table 4. Summary of performance of entries in the Advance hulless test at 3-locations (Blacksburg, Painter and Warsaw) in Virginia, 2006 harvests*.

LINE	Yield Bu/a	Test weight lb/bu	Heading date (Mar 31+)	Height (in)	Lodging (0.2-10)[1]	Leaf Rust (0-9)	Net Blotch (0-9)	Spots (0-9)
VA03H-61	89.8	60.8	20.0	30.3	1.0	3.0	1.0	0.0
VA04H-113	88.2	59.0	16.3	32.2	1.7	1.5	1.3	1.5
VA04H-114	87.2	58.6	16.5	31.0	1.2	1.4	1.0	1.0
Eve	86.2	58.3	13.5	31.0	0.7	1.9	2.0	1.5
VA04H-112	86.0	58.7	15.8	34.3	3.7	6.6	1.0	0.0
VA04H-86	85.9	58.1	13.5	31.7	2.3	3.1	2.3	1.5
VA04H-111	84.8	59.2	16.8	31.8	1.4	2.0	1.3	0.5
VA01H-1	84.6	58.1	15.5	31.5	0.5	2.4	1.7	3.0
VA03H-64	84.5	58.5	17.5	34.5	2.3	5.5	1.0	0.0
VA04H-53	82.7	58.5	21.0	32.2	2.2	3.3	1.7	1.0
VA04H-59	82.3	58.5	17.7	35.2	2.0	2.9	1.0	0.0
VA04H-95	82.1	58.6	17.8	34.5	0.7	2.3	2.0	1.0
Doyce	81.4	57.6	16.5	28.7	1.0	0.9	4.0	3.0
VA01H-125	80.0	58.6	13.5	25.7	1.2	4.6	2.3	1.0
VA03H-100	79.6	58.9	18.7	34.8	2.0	5.0	2.0	0.0
VA04H-98	79.4	59.0	17.3	32.3	1.3	2.4	2.3	1.5
VA04H-35	79.3	57.4	16.3	32.5	3.0	3.8	1.7	1.0
VA04H-25	78.6	61.1	17.2	32.2	0.9	2.3	1.0	0.5
VA03H-58	76.1	59.8	21.0	26.0	2.1	3.0	1.0	0.0
VA04H-56	75.9	58.8	14.7	30.8	4.3	5.3	2.7	0.5
VA04H-122	75.6	58.2	14.0	30.2	2.0	2.1	2.7	2.5
H-585	75.4	57.6	12.8	30.8	1.4	4.5	2.3	1.5
VA04H-24	73.7	59.4	18.2	31.5	2.7	3.1	2.0	0.0
VA04H-26	72.1	60.3	16.5	28.7	1.7	2.3	1.0	0.5
VA04H-32	69.4	58.7	13.8	24.5	1.0	4.8	1.0	1.5
GRAND MEAN	80.8	58.8	16.5	31.2	1.8	3.2	1.7	1.0
CV %	10.2	0.9	6.8	5.7	58.0	32.9	34.6	60.8
LSD (0.05)	8.2	0.5	1.3	2.0	1.0	1.0	1.0	1.2

[1]Belgian Lodging Scale = Area x Intensity x 0.2. Area is rated on a scale from 1 (plot unaffected) to 10 (entire plot affected).
Intensity is rated on a scale from 1 (plants standing upright) to 5 (plants lying flat on the ground).
[2] All 0-9 ratings indicate relative disease severity: 0 = no disease present; 9 = total infestation of the plants by disease.

Three year (2002-2005) summary of Compositional analysis of hulless, hulled and malt barley lines conducted by the USDA-ARS, Eastern Regional Research Center in Pennsylvania in order to characterize and improve the quality of barley for specific end uses are presented in Table 5. Average starch concentration among hulless lines (Table 5) ranged from 56.97 % (VA01H-125) to 63.67 % (Doyce). Average beta glucan content ranged from 3.70 % (VA01H-13) to 5.45% (VA01H-125) and average protein levels varied from 8.72 % (VA01H-26) to 10.47% (VA01H-122). Average ash content varied from 1.30% to 2.02%.

Table 5. Three-Year Average summary of Compositional Analysis of Barley (Hulless, Hulled and Malt) Lines conducted in 2002-2005.

LINE	Test Weight (lb/bu)	STARCH (%)	BETA GLUCAN (%)	PROTEIN (%)	ASH (%)	OIL (%)
Eve	59.04	61.14	4.18	9.81	1.93	2.52
Doyce	56.34	63.67	3.83	9.04	1.80	2.44
H-585	58.61	61.07	4.41	9.16	1.96	2.44
VA00H-10	57.84	60.11	4.49	9.32	1.98	2.49
VA00H-65	59.59	61.08	4.48	9.29	1.90	2.39
VA00H-70	58.68	59.74	4.64	9.30	2.02	2.40
VA00H-72	58.69	60.72	4.36	9.02	1.99	2.44
VA00H-74	57.49	60.67	4.47	8.88	1.99	2.49
VA00H-99	58.51	61.30	4.30	9.14	1.99	2.53
VA01H-1	59.18	60.49	3.84	9.14	1.90	2.38
VA01H-26	56.57	62.40	3.75	8.72	1.90	2.31
VA01H-37	56.78	60.10	4.06	9.16	1.94	2.31
VA01H-44	56.42	62.32	3.91	8.76	1.95	2.29
VA01H-13	57.12	62.26	3.70	8.97	1.97	2.36
VA01H-3	57.99	61.40	3.80	9.01	1.94	2.47
VA01H-122	59.48	59.45	4.57	10.47	2.00	2.57
VA01H-124	58.93	59.00	5.38	9.40	1.89	2.56
VA01H-125	59.58	56.97	5.45	9.82	1.93	2.48
MEAN: Hulless	**58.16**	**60.77**	**4.31**	**9.25**	**1.94**	**2.44**
MAX: Hulless	**59.59**	**63.67**	**5.45**	**10.47**	**2.02**	**2.57**
MIN: Hulless	**56.34**	**56.97**	**3.70**	**8.72**	**1.80**	**2.29**
Callao	49.36	57.83	4.06	9.15	2.22	2.45
Nomini	47.60	55.98	4.27	9.08	2.33	2.24
Price	48.84	55.38	4.10	9.13	2.18	2.32
Thoroughbred	48.80	60.39	3.91	9.24	2.31	2.42
VA92-42-46	46.24	54.51	3.78	9.80	2.48	2.06
VA96-44-304	47.97	54.73	4.68	9.33	2.30	2.27
MEAN: Hulled	**48.13**	**56.47**	**4.13**	**9.29**	**2.30**	**2.29**
MAX: Hulled	**49.36**	**60.39**	**4.68**	**9.80**	**2.48**	**2.45**
MIN: Hulled	**46.24**	**54.51**	**3.78**	**9.08**	**2.18**	**2.06**
Plaisant	51.19	56.85	3.90	9.83	2.28	2.48
92Ab1841	49.21	57.99	3.70	8.88	2.32	2.39
95Ab2299	49.51	58.44	3.90	8.80	2.11	2.34
94Ab1261	48.06	59.71	3.79	8.66	2.18	2.36
Novosadski 183	52.69	61.20	4.19	8.73	2.13	2.35
Novosadski 293	52.72	60.66	4.04	9.52	2.13	2.30
94Ab1274	45.87	59.36	3.80	9.08	2.25	1.92
94Ab1347	49.65	60.76	4.07	8.29	2.04	2.32
MEAN: Malt	**49.86**	**59.37**	**3.92**	**8.98**	**2.18**	**2.31**
MAX: Malt	**52.72**	**61.20**	**4.19**	**9.83**	**2.32**	**2.48**
MIN: Malt	**45.87**	**56.85**	**3.70**	**8.29**	**2.04**	**1.92**

Average starch content among six hulled barley lines was lower than the hulless barley lines and ranged from 54.51% (VA92-42-46) to 60.39 % (Thoroughbred). Average beta glucan content ranged from 3.78 % (VA92-42-46) to 4.68 (VA96-44-304). Average protein content ranged from 9.08 % (Nomini) to 9.80 % (VA92-42-46) and Average ash content ranged from 2.18 to 2.48 %.

Average starch content for the malt barley was similar to the hulless but higher then the hulled barleys and ranged from 56.85 % (Plaisant) to 61.20 % (Novosadski 183). Average beta glucan content among the malt barley was lowest for all barley types and ranged from 3.70 % (92Ab1841) to 4.19 % (Novosadski 183) and average protein content varied from 8.92 % to 9.83 %. Average oil content was similar for all barley categories (hulless, hulled and malt) and ranged from 1.92 % to 2.48 %.

Efforts are continuing to develop barley lines with low phytic acid content by making crosses between low phytic acid, spring barley mutant lines and some of our superior hulled and hulless barley lines. Development of low phytic acid barley lines will benefit both the environment and the poultry and swine industries by improving the nutritional value of barley fed to poultry and swine as well as providing a means for reducing waste-derived phosphorus pollution. We also will continue to work with animal scientists, swine and poultry nutritionists, and industry personnel to determine the potential benefits of hulless barley as a feed component and what improvements are needed to make winter barley a more acceptable feed stock.

Chemical and nutritional analyses conducted by the USDA-ARS Eastern Regional Research Center on grain samples of our advanced hulled and hulless barley lines will further determine the potential benefits of hulless barley as a feed, food and fuel ingredient. Significant commercial interest exists for use of hulless barley in ethanol production, and we will continue to work with interested parties in evaluating the potential of hulless barley for this purpose.

Project Component: Hulless Barley Management

Summary of completed project activities:

Experiment: Appropriate seeding rate for hulled and hulless barley in Virginia

One hulless barley seeding rate trial was planted at the Eastern Virginia AREC in the fall of 2006. At EVAREC, all plants in 0.9 m from the two center rows of each plot were counted prior to the onset of tillering to determine the number of plants m^{-2} (Table 1). The same area within each plot was evaluated for heads m^{-2} in May 2007. Based on 2004-2006 results, increasing seeding rates increased the number of plants for both hulled and hulless barley, the number of harvestable heads was optimized by seeding rates of 600 seeds m^{-2} for hulled barley and 700 seeds m^{-2} for hulless barley in 2006 (Table 2). Grain yield as related to hull characteristics and seeding rate are presented in Table 3. Yield components fro the current year's testing will be calculated in the summer of 2007.

Results from 2004-2007 indicate that while recommended hulled barley seeding rates are appropriate, seeding rates for hulless barley may need to be increased as much as 50% (to 500 seeds m^{-2}) above current recommendations

323 seeds m^{-2} — Thoroughbred | VA01H-68

646 seeds m^{-2} — Thoroughbred | VA01H-68

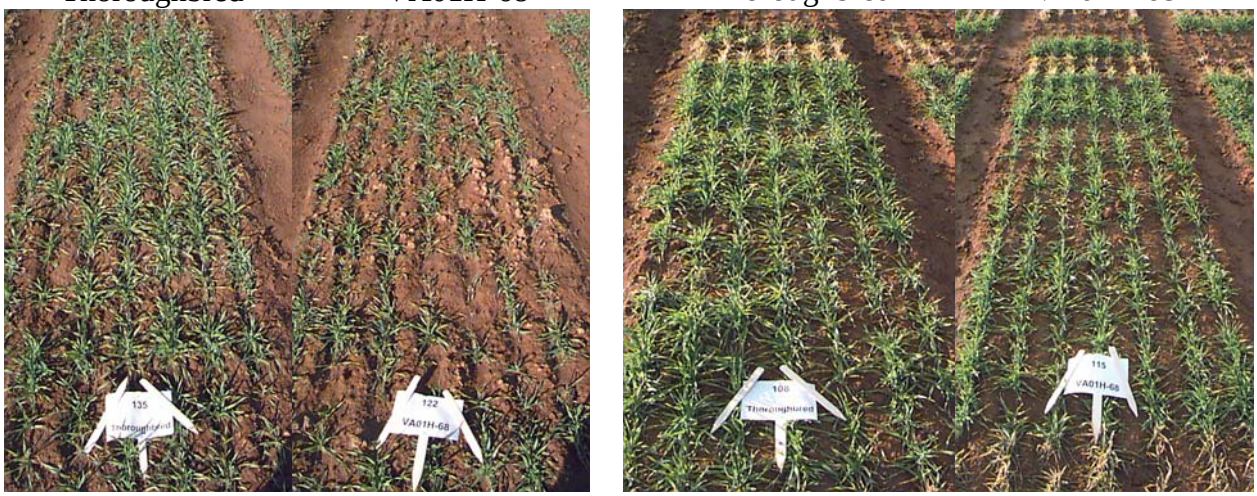


Table 1. Seeding rates and preliminary yield components for hulled and hulless entries, EVAREC, Warsaw, VA, 2007.

	Warsaw							
	Hulled				Hulless			
seed rate								
seeds m^{-2}	plants m^{-2}	heads m^{-2}	kernels hd^{-1}	weight $kernel^{-1}$	plants m^{-2}	heads m^{-2}	kernels hd^{-1}	weight $kernel^{-1}$
	number			mg	number			mg
323	252	303	.†	.	149	281	.	.
430	298	269	.	.	197	331	.	.
538	362	294	.	.	230	290	.	.
646	421	341	.	.	284	341	.	.
753	512	339	.	.	310	349	.	.
861	546	321	.	.	334	350	.	.

seeds m^{-2} (x), plants m-2 (y)	Y=57.996+.5755x R^2 = 0.9893**	Y=43.964+.3495x R^2 = 0.9843**
seeds m^{-2} (x), heads m-2 (y)	Y=256.8+.092x R^2 = 0.4423*	Y=252.8+.1195x R^2 = 0.6204*
heads m^{-2} (x), kernels hd^{-1} (y)	. .	. .
heads m^{-2} (x), weight $kernel^{-1}$ (y)	. .	. .

*, ** Significant at the 5% and 1% probability level, respectively
† To be determined after harvest

Table 2. Seeding rates and yield components for hulled and hulless entries, EVAREC, Warsaw, VA, 2006.

	Warsaw							
	Hulled				Hulless			
seed rate								
seeds m^{-2}	plants m^{-2}	heads m^{-2}	kernels hd^{-1}	weight $kernel^{-1}$	plants m^{-2}	heads m^{-2}	kernels hd^{-1}	weight $kernel^{-1}$
	number			mg	number			mg
323	329	434	38	39	175	491	30	32
430	369	455	34	39	234	510	31	31
538	498	521	31	39	273	537	30	31
646	593	553	27	39	344	631	25	31
753	761	631	25	38	399	605	26	31
861	822	602	27	38	448	733	22	30

seeds m^{-2} (x), plants m-2 (y)	Y=- 24.967 + 0.9918 R^2 = 0.9784**	Y= 8.7915+.5126x R^2 = 0.9963**
seeds m^{-2} (x), heads m-2 (y)	Y=312.73 + 0.3716x R^2 = 0.9091**	Y=334.76 + .422x R^2 = 0.8765**
heads m^{-2} (x), kernels hd^{-1} (y)	Y=63.362-.0623x R^2 = 0.9206**	Y=47.525-.0344x R^2 = 0.9459**
heads m^{-2} (x), weight $kernel^{-1}$ (y)	Y=40.501-.0036x R^2 = 0.5517**	Y=33.814-.0046x R^2 = 0.6901**

*, ** Significant at the 5% and 1% probability level, respectively

Table 3. Grain yield and regression functions for hulled and hulless lines, 2004-2006.

	Hulled					Hulless				
	Blacksburg 2004	Warsaw 2004	Warsaw 2005	Chatham 2005	Warsaw 2006	Blacksburg 2004	Warsaw 2004	Warsaw 2005	Chatham 2005	Warsaw 2006
seeds m^{-2}	Grain Yield, kg ha^{-1}									
323	.	.	6571	5051	5961	.	.	4657	3245	4461
430	4496	6629	7244	5322	5904	2630	4147	4833	3354	4518
538	4421	7047	6767	5518	6031	2701	4648	4850	3758	4721
646	4706	7391	6775	4652	5792	3059	5038	5311	3426	4828
753	4490	7646	6833	5395	5900	3012	5169	5482	3696	4775
861	.	.	6960	5654	6079	.	.	5502	3929	4705

Linear	$Y=5641.9 + 0.664x$	$Y=3526 + 1.4604x$
	$R^2=0.6618$**	$R^2=0.7957$
Quadratic	$Y=6230.9-1.8929x+0.0025x^2$	$Y=4489.2-2.7223x-0.0041x^2$
	$R^2=0.8352$**	$R^2=0.9111$**

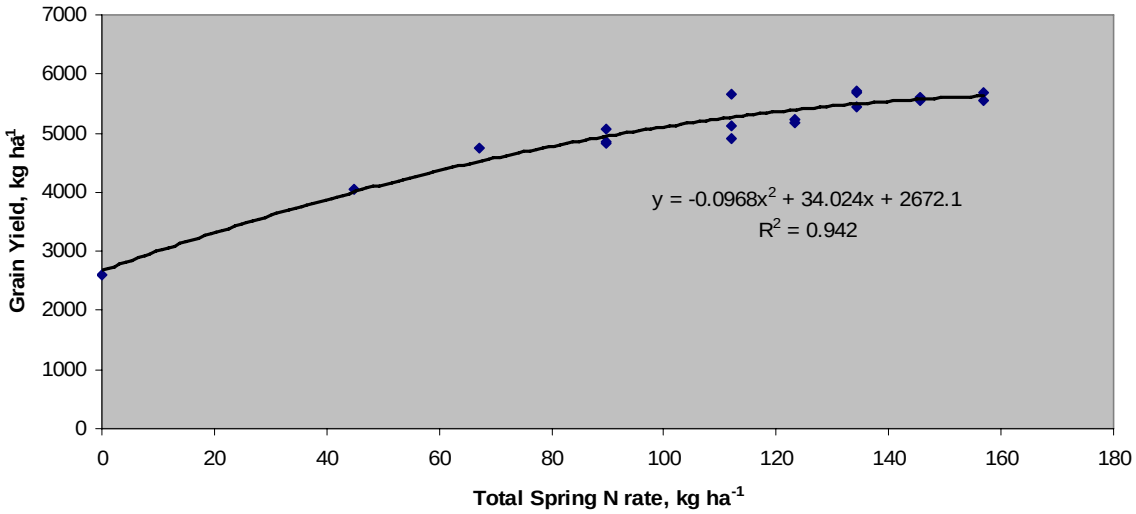
*, ** Significant at the 5% and 1% probability level, respectively

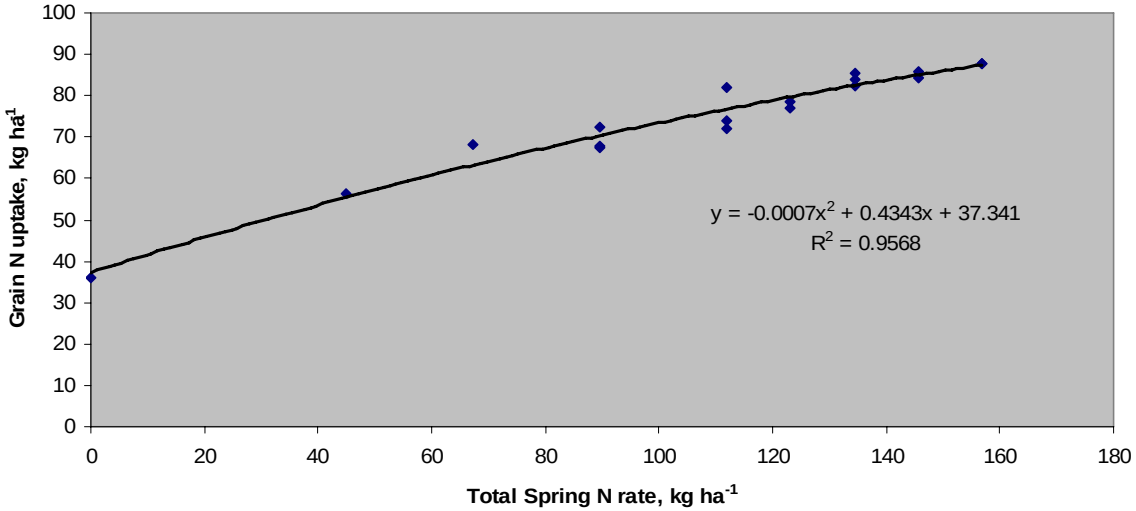
Experiment: Optimizing spring nitrogen rates for hulless barley

Timeline: Fall 2004 to Summer 2007

Trials were planted at the Eastern Shore AREC, Tidewater AREC, and Westover Plantation in Charles City County, in the fall of 2006. Rates of nitrogen (N) ranging from zero to 160 kg N ha^{-1} were applied in different combinations in late winter and in early spring. In the initial years of evaluation, we observe a curvilinear response of grain yield and grain protein to increased spring N rate (Figure 1). Initial results indicate optimum spring N rates in the range of 100 to 120 kg ha^{-1}.

Figure 1. Hulless barley grain yield and grain N uptake response to spring N rate.





Project Component: Bread Wheat Management

Experiment: Bread Wheat Seeding Rate

Timeline: Fall 2004 to Summer 2007

Seeding rate trials were planted at the Tidewater AREC and in Shenandoah County in the fall of 2006. Plots were planted into conventionally tilled fields at rates of 278, 371, 464, 557, and 646 seeds m^{-2} at both sites. All plants in 0.9 m of row from the two center rows of each plot were counted prior to the onset of tillering to determine the plant density achieved at each seeding rate. Data from the 2006-07 season will be summarized after grain harvest. We observed the following in preliminary testing in 2005 and 2006. A quadratic effect of seeding rate on early season plant density was observed across sites in 2006 (Figure 1). Seeding above 600 seeds m^{-2} resulted in fewer plants than rates just below this threshold. Figure 2 demonstrates that the number of heads was increased with increased seeding rate up through 646 seeds m^{-2}. Yield was also increased with seeding rate, even at what would normally be considered extremely high rates. This effect may have been due to the extremely dry early spring experienced at both sites. Tillers were aborted due to lack of moisture and the higher seeding rates, which generally produce more main stem heads and fewer tillers, may have had a more developed root system and a greater ability to avoid drought.

Effect of Seeding Rate on Bread Wheat Stands.

Figure 1. Plant density by seeding rate, 2006.

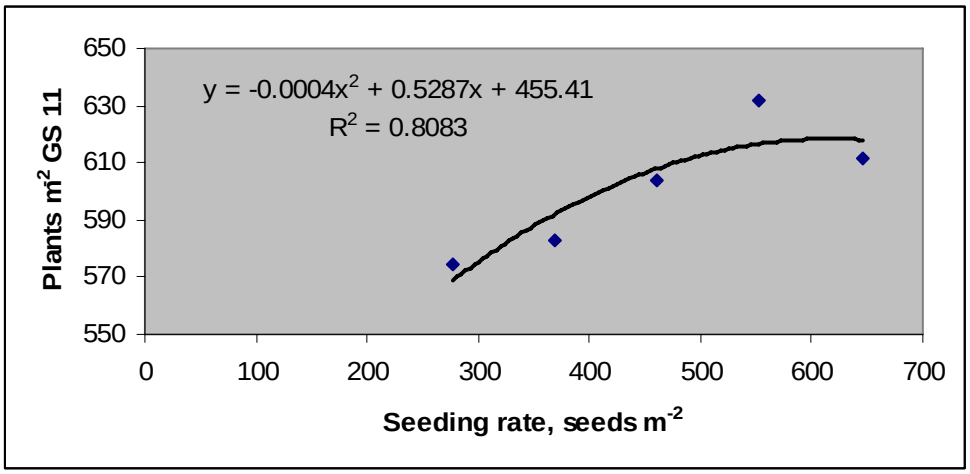


Figure 2. Head density at harvest, 2006.

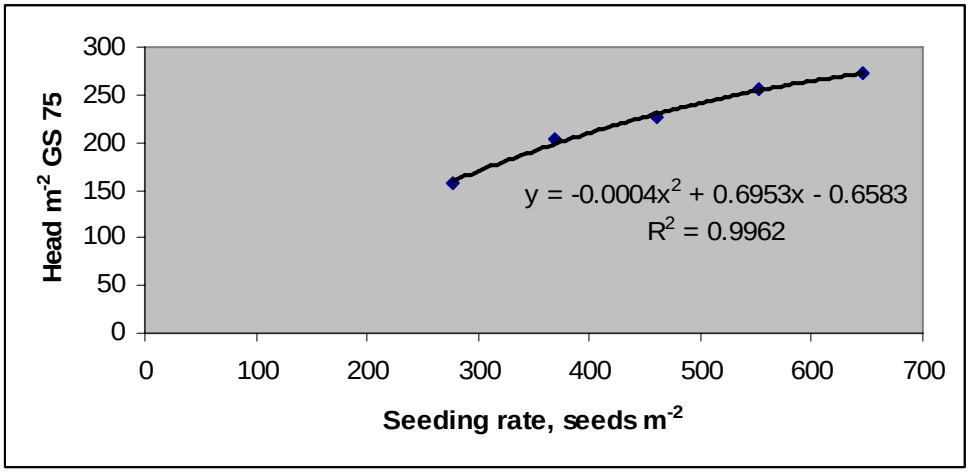
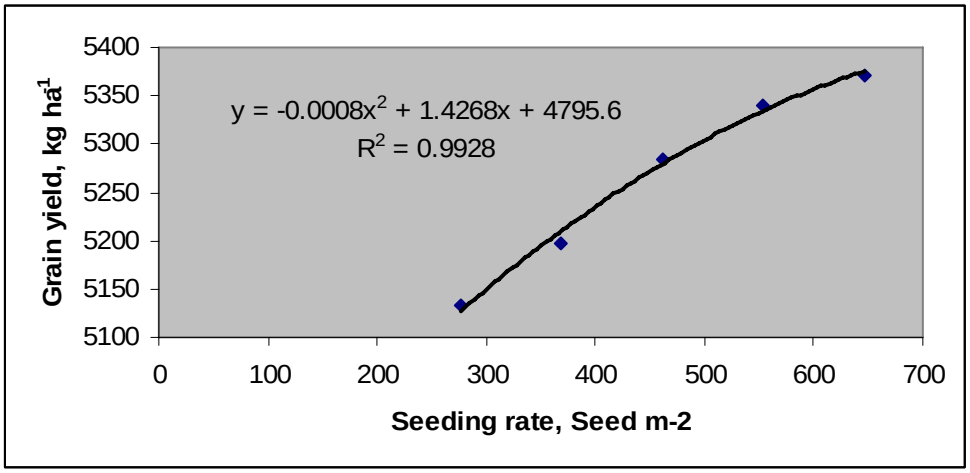


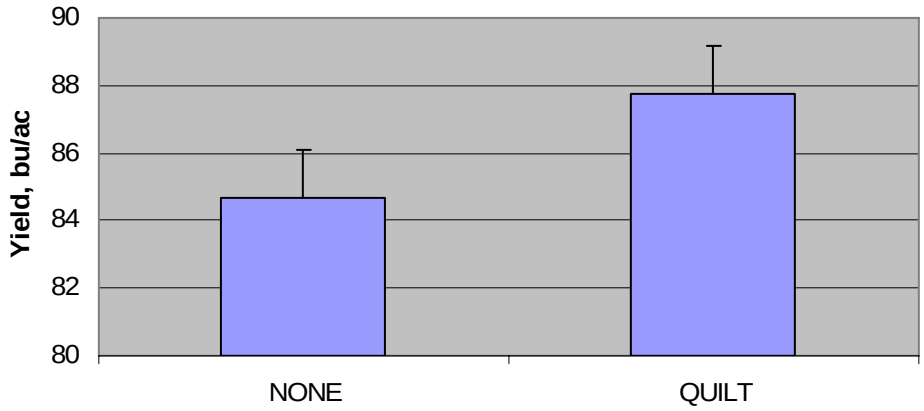
Figure 3. Grain yield at harvest as affected by seeding rate, 2006.



Bread Wheat Disease Studies
Timeline: Fall 2004 to Summer 2007

One trial was planted at the Eastern Virginia AREC and one at the Eastern Shore AREC in Fall, 2006 to evaluate the necessity and effectiveness of fungal disease control in potential bread wheat cultivars. One half of all plots received a seed application of Baytan® fungicide to limit fall infection of powdery mildew (PM), however fall and winter PM incidence was low at both locations so no fall disease evaluations occurred. An application of the recommended label rate of Quilt® fungicide was applied to predetermined plots in both trials at flag leaf emergence in the spring of 2007. For some plots, this control measure was in addition to the Baytan®, while in others, it was the only control. As in previous years, both trials were rated for disease severity this spring and these ratings are being compiled at the time of this report. Grain yield and yield components are likewise still being determined. Data from 2006 evidenced a yield increase of approximately 3 bu/ac due to fungicide application across cultivars (Figure 4).

Figure 4. Bread wheat cultivar yield response to 14 oz Quilt fungicide applied at GS 37.



Grain samples from 2005 were evaluated for milling and baking characteristics to determine if disease or control measures affected grain quality parameters. Fungicide application significantly increased bread loaf weight, but had little other consistent benefit. The 2005 season had very little disease development and the incidence of disease may heavily affect the potential milling and baking benefits from a fungicide application.